



# White Rabbit Management and Monitoring

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# Agenda

- A few words about myself
- Short overview of White Rabbit network and equipment
- Supported protocols for monitoring and management
- Command line tools



# Who am I?

(In the context of White Rabbit Management and Monitoring)

- Worked at CERN for 5 years (2014-2019)

During this time:

- Maintainer of White Rabbit Switch software
  - Over 900 commits
  - Integrated SNMP, LLDP, Kerberos+LDAP daemons
  - Implemented WR-SWITCH-MIB
- Key developer of WRPC software (WR node)
  - Over 500 commits
  - Developed SNMP agent
  - Developed LLDP daemon
- Involved in the design of configuration tool for WRS at CERN
- Supported integration of WRS and WRPC monitoring at CERN
- Implemented White Rabbit dissector for Wireshark sniffer

- Since 2020:

Independent White Rabbit and Embedded Systems consultant:

- Implemented BRIDGE-MIB and Q-BRIDGE-MIB for WRS
- Implemented VLAN support for LLDP
- Author of MIB for IEEE 1588 (PTP) standard



# Agenda

- A few words about myself
- **Short overview of White Rabbit network and equipment**
- Supported protocols for monitoring and management
- Command line tools

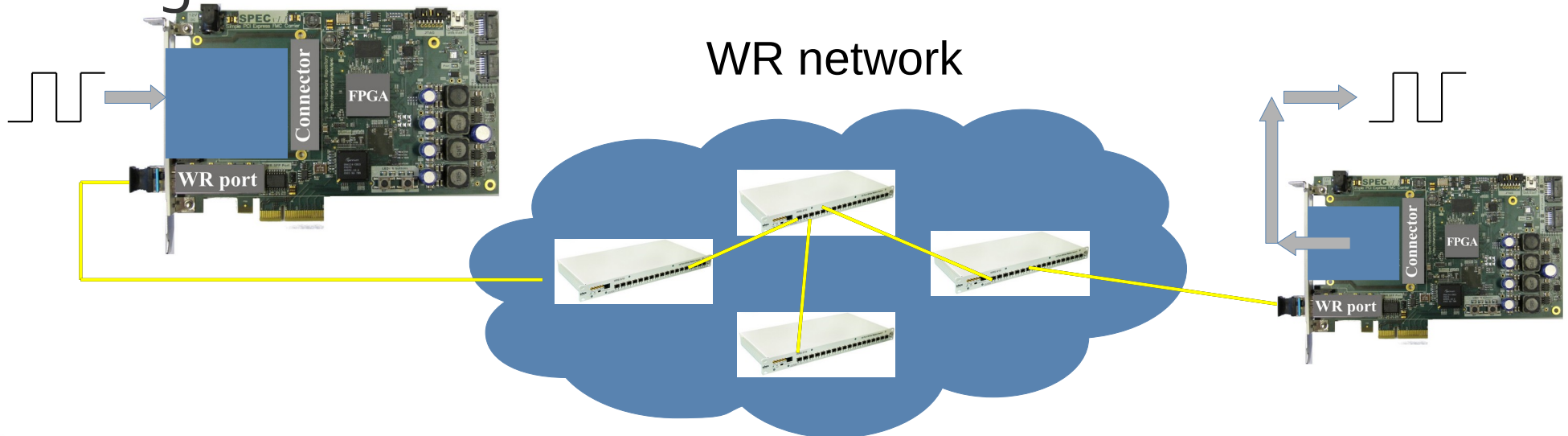


# Transmission medium

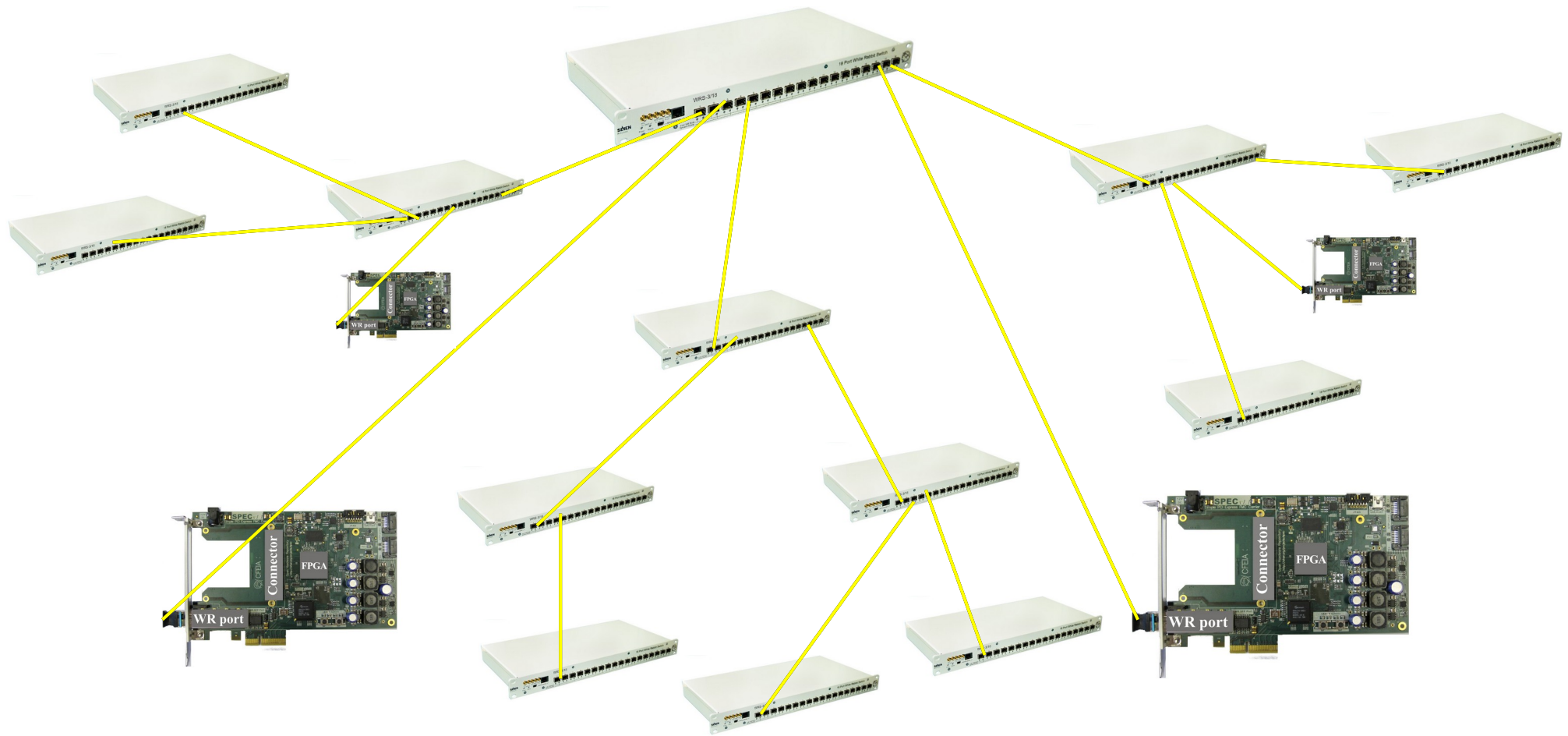
- e.g. coaxial cable



- Using White Rabbit



# Example White Rabbit network



- Challenging to manage big network



# White Rabbit Switch (WRS)

- 18x 1GbE ports (SFP)
  - Supports 1Gb SFPs (fiber, copper (no WR))
  - WR supported only on some fiber SFPs
- 1x 100Mbit Management port (RJ-45)
- White Rabbit network is separated from management
  - It is possible to hack, but limited throughput (~1MBit/s)

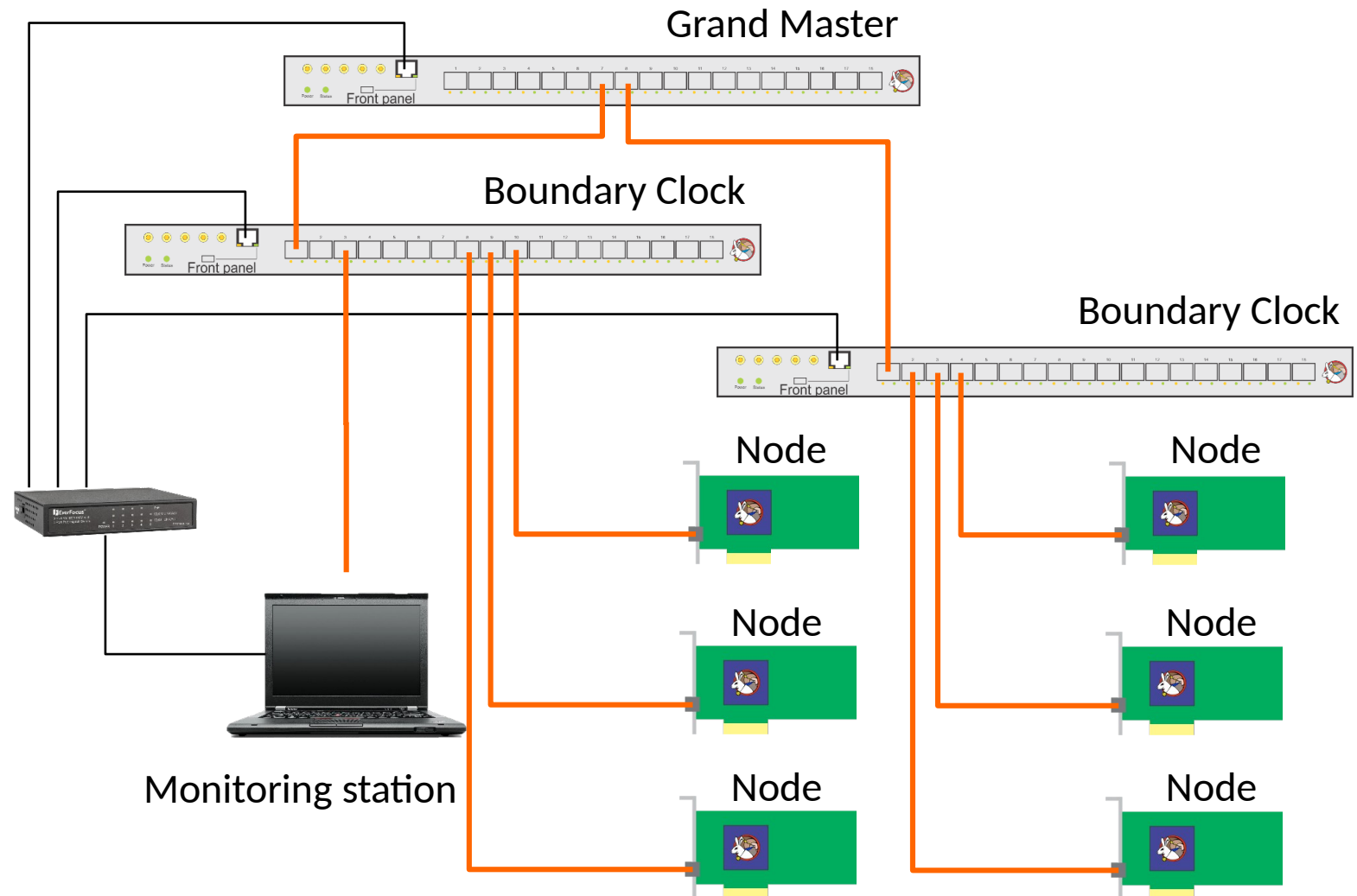


More information about WR switch:

<https://ohwr.org/project/white-rabbit/wikis/SummaryWRProjects#switch-related>



# Monitoring of White Rabbit network





# White Rabbit Node

- White Rabbit PTP Core (WRPC)
- Usually 1x 1GbE WR port
- In a host or standalone mode
- Management and Monitoring functions implemented in Soft Core CPU (LM32) in FPGA
- Very limited resources (esp. memory)
- In form of different standards:
  - PICE: SPEC
  - VME: SVEC, VFC-HD
  - CPCI: SPEXI
  - uTCA



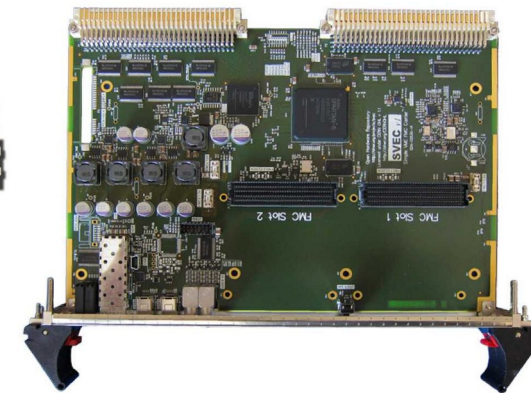
FMC &  
CompactRIO



PCI  
Express

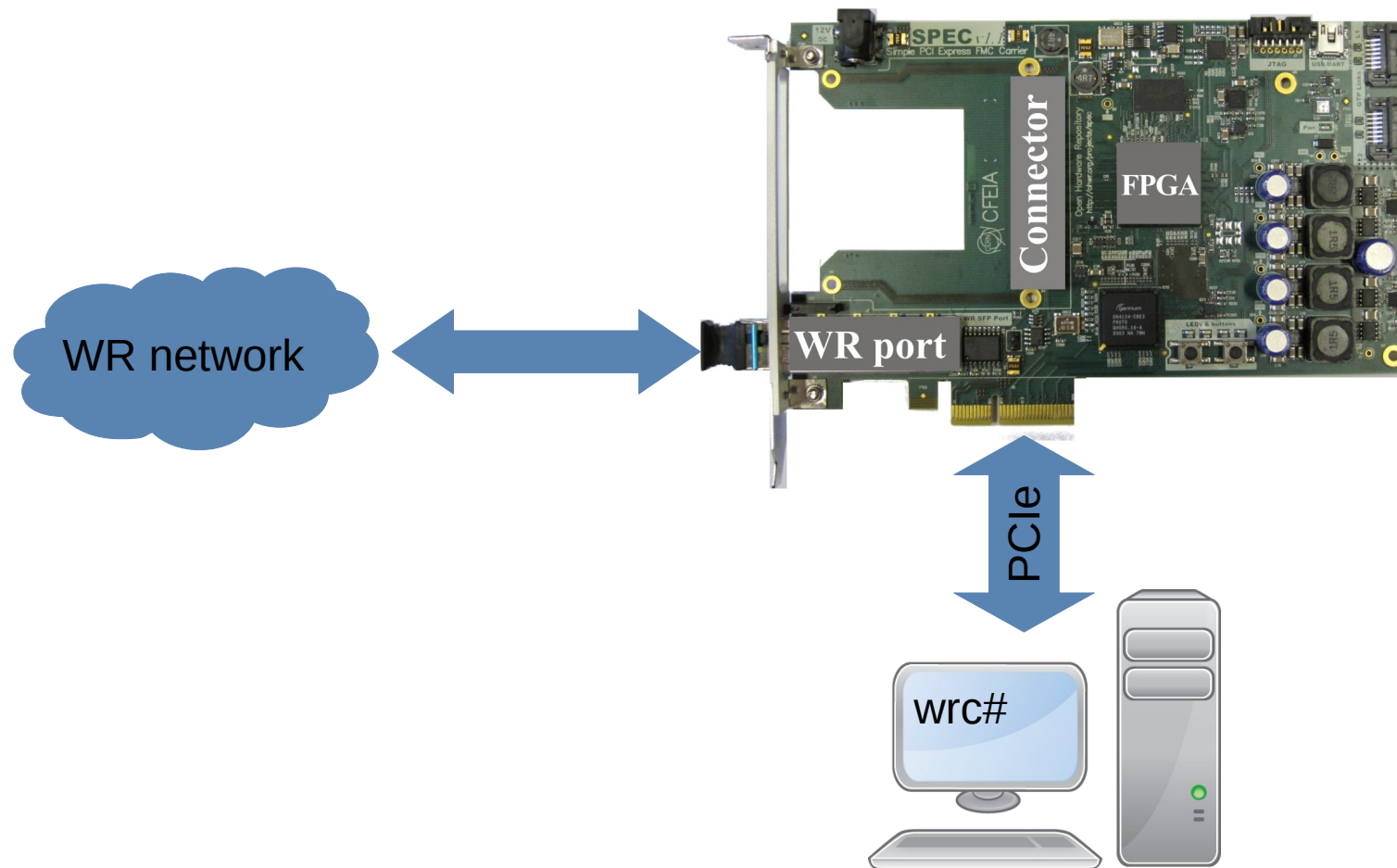


PXI  
Express



VME

# WRPC: communication



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- **Supported protocols for monitoring and management**
- Command line tools



# White Rabbit

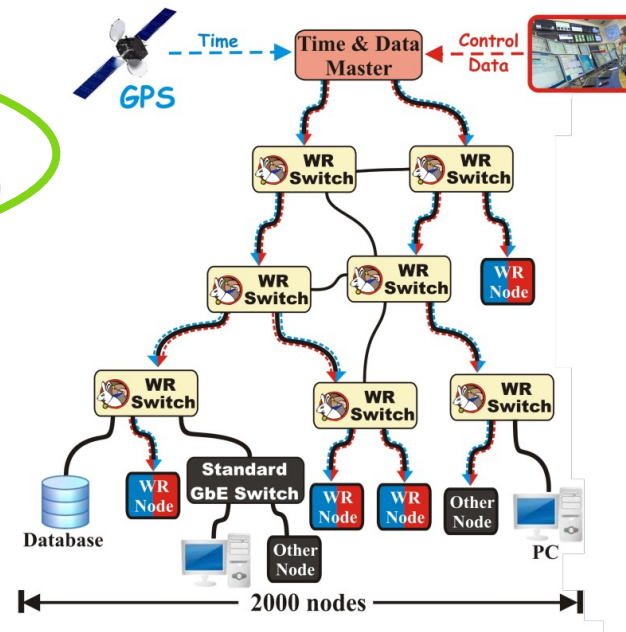
Intro to WR  
●○○○○○

WR Community  
○○○○○○

This Workshop  
○○○

## What is White Rabbit?

- Initiated to renovate CERN's and GSI's accelerator timing systems
- **Based on well-established standards**
  - Ethernet (IEEE 802.3)
  - Bridged Local Area Network (IEEE 802.1Q)
  - Precision Time Protocol (IEEE 1588)
- **Extends standards** to meet new requirements and provides
  - Sub-ns synchronisation
  - Deterministic data transfer
- Initial specs: links  $\leq 10$  km &  $\leq 2000$  nodes
- **Open Source and commercially available**



Javier Serrano | CERN BE-CEM-EDL

White Rabbit

4/17

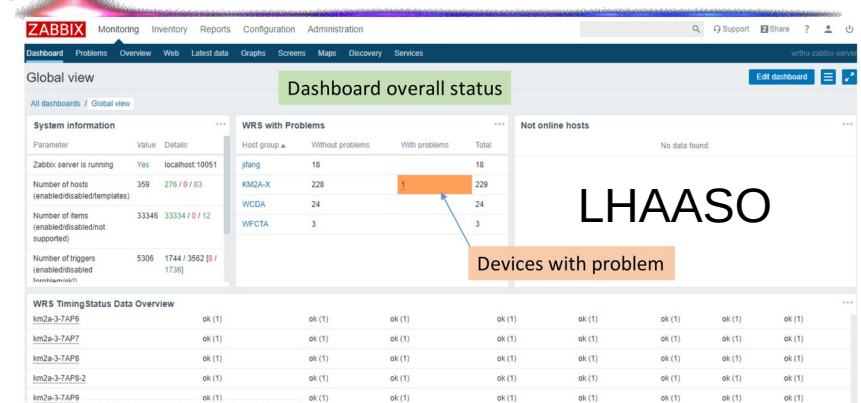
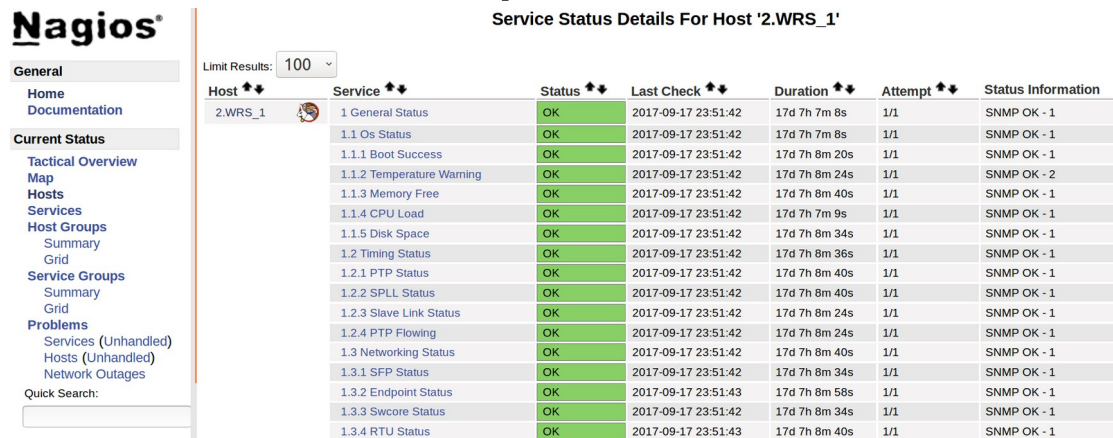
Source: [https://ohwr.org/project/white-rabbit/wikis/uploads/da6d8abed6402112c5c1c0278b422299/wr\\_ws11\\_intro\\_2021\\_10.pdf](https://ohwr.org/project/white-rabbit/wikis/uploads/da6d8abed6402112c5c1c0278b422299/wr_ws11_intro_2021_10.pdf)

## Let's use it!



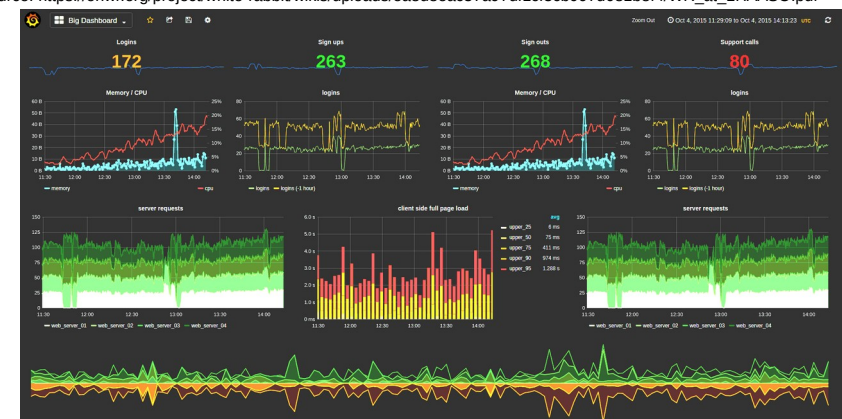
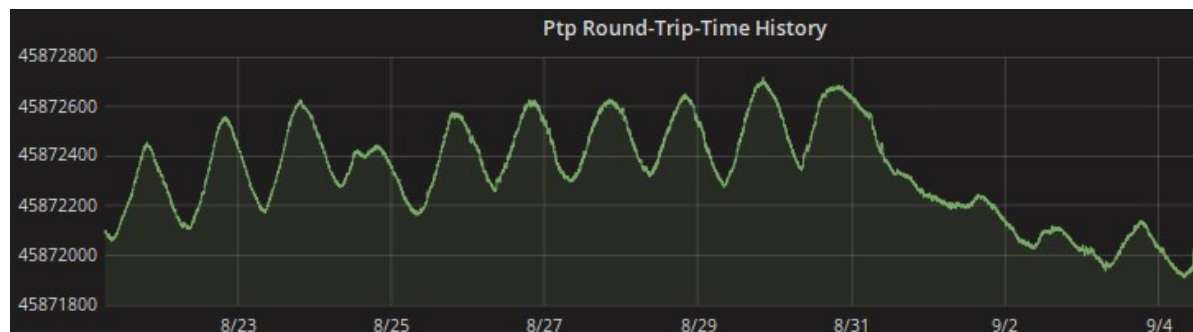
# Network monitoring (SNMP)

- Timing monitoring (Sync status)
- WRS: more than 300 specific parameters
- WRPC: ~70 parameters



**Monitor:** WRS sync status, packet flow of WRS port, RTT, temperature, etc..

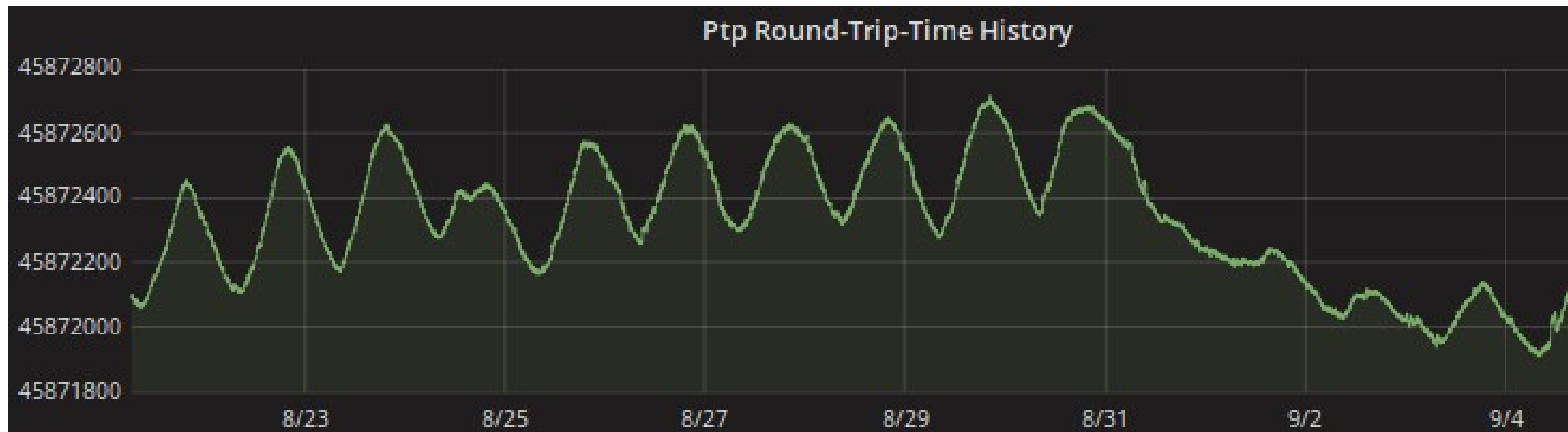
Source: [https://ohwr.org/project/white-rabbit/wikis/uploads/ea8d8eac37a97d1cf3cb097d081b8f4/WR\\_at\\_LHAASO.pdf](https://ohwr.org/project/white-rabbit/wikis/uploads/ea8d8eac37a97d1cf3cb097d081b8f4/WR_at_LHAASO.pdf)





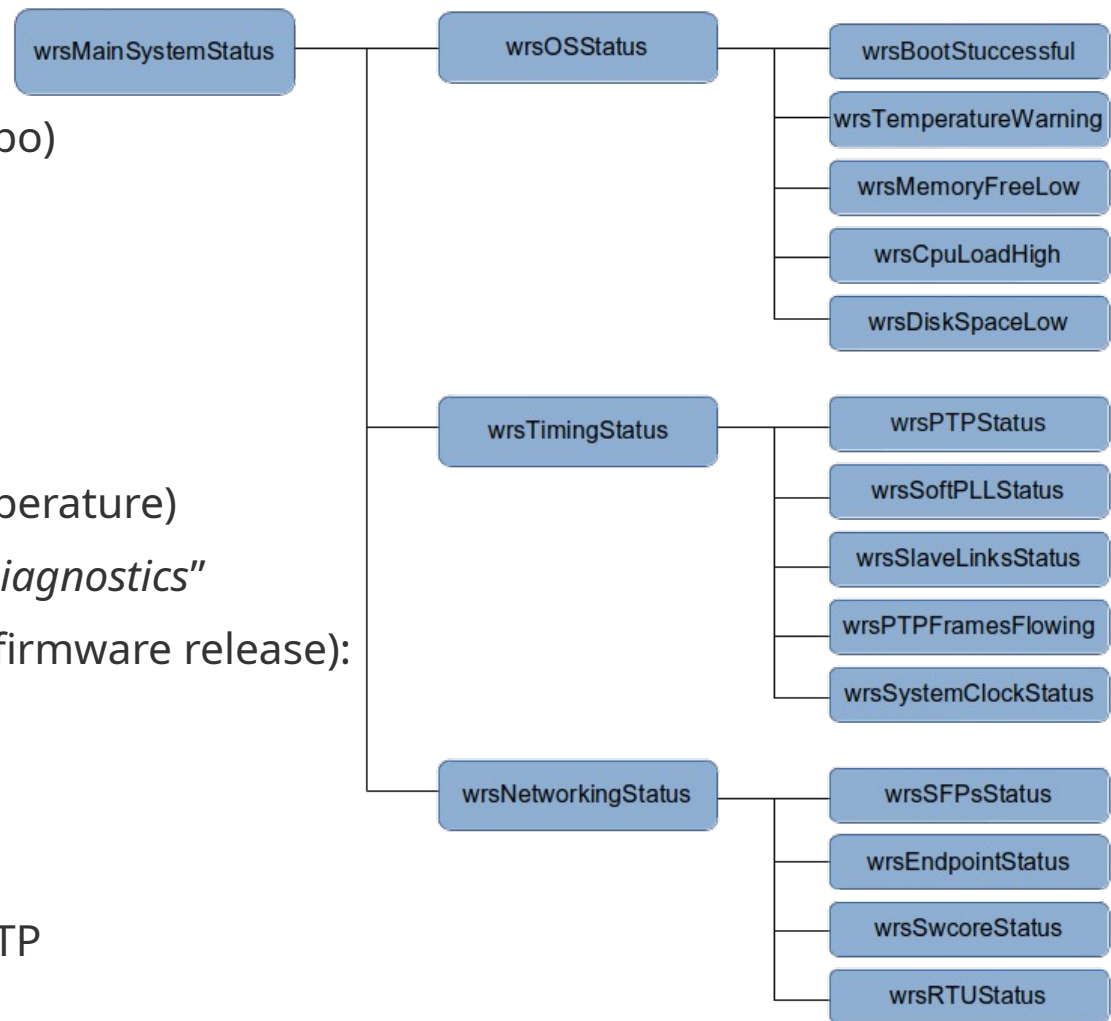
# Monitoring example

- Is the correction by White Rabbit needed?
- Link ~5km, underground
- ~400ps RTT difference between day and night
- >1ns due to the weather



# WRS: SNMP

- WR-SWITCH-MIB (in wr-switch-software repo)
  - status OIDs
  - expert OIDs like:
    - Port status and configuration
    - Timing status and configuration
    - SFP monitoring (e.g. vendor, temperature)
- More in “*White Rabbit Switch: Failures and Diagnostics*”
- Standard MIBs (to be included in the next firmware release):
  - MIB-IP
  - Q-BRIDGE-MIB (VLANs)
  - BRIDGE-MIB (MAC routing tables)
  - Ongoing standardization of MIB for PTP
    - Implementation in the future
- Note: SNMP cannot be used to change the configuration of WRS



# WR Switch: Failures and Diagnostics

- Document published with WR Switch firmware release
- Lists various errors reported by a switch
- Analyses problems that cause the error
- Proposes actions to mitigate problems
- Similar document exists for WRPC (node)

White Rabbit Switch: Failures and Diagnostics

Grzegorz Daniluk  
Adam Wujek

CERN BE-CO-HT  
wr-switch-sw-v5.0

December 16, 2016





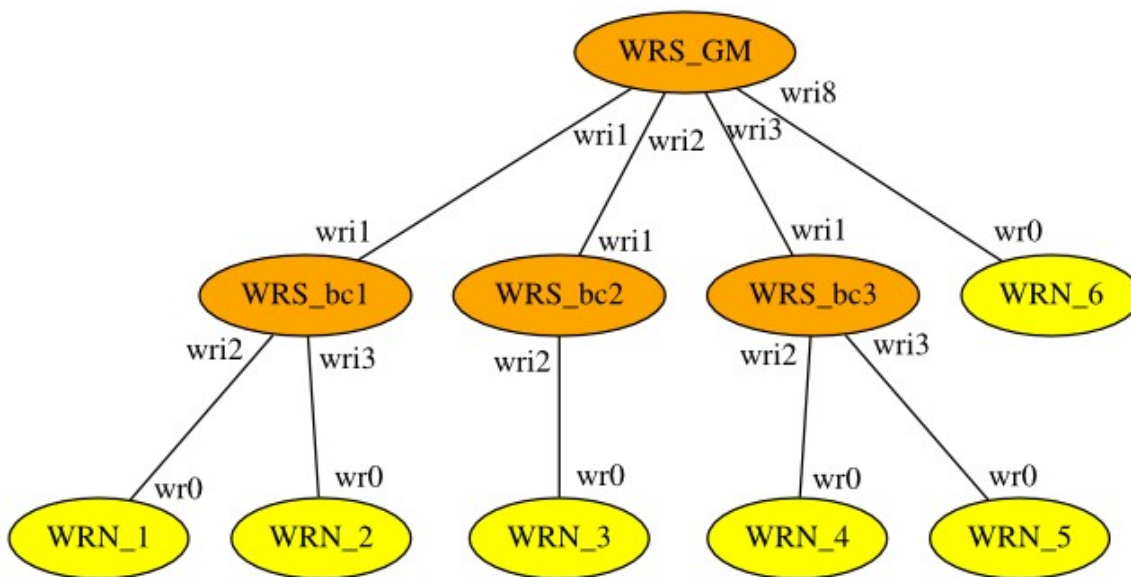
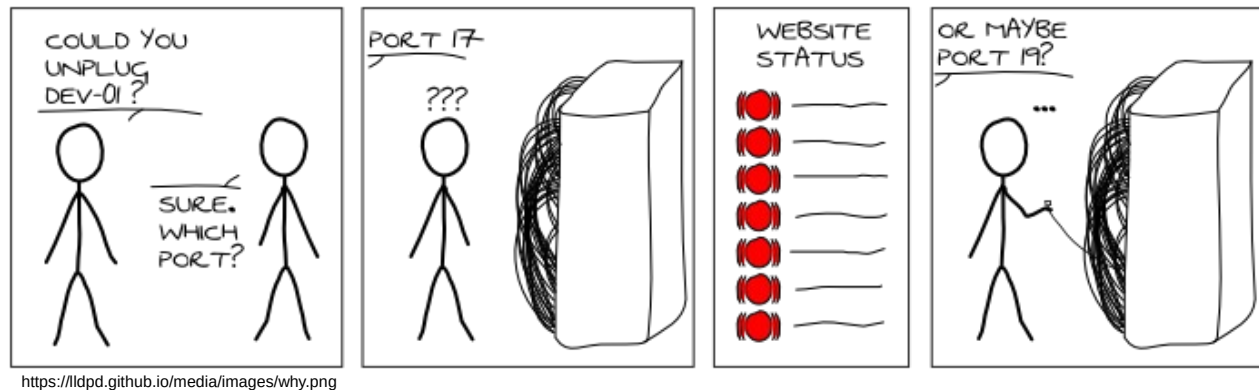
# WRPC: SNMP

- WR-WRPC-MIB (in wrpc-sw repo)
  - No status OIDs
  - Port's statistics
  - PTP/WR timing status and configuration
  - SFP calibration database
  - SFP monitoring (temperature, RX/TX power)
- SNMP can be used to configure some parameters:
  - SFP database
  - Init script
  - Remote shell command execution
- Not Secure! No SNMP v3



# Network Topology (LLDP)

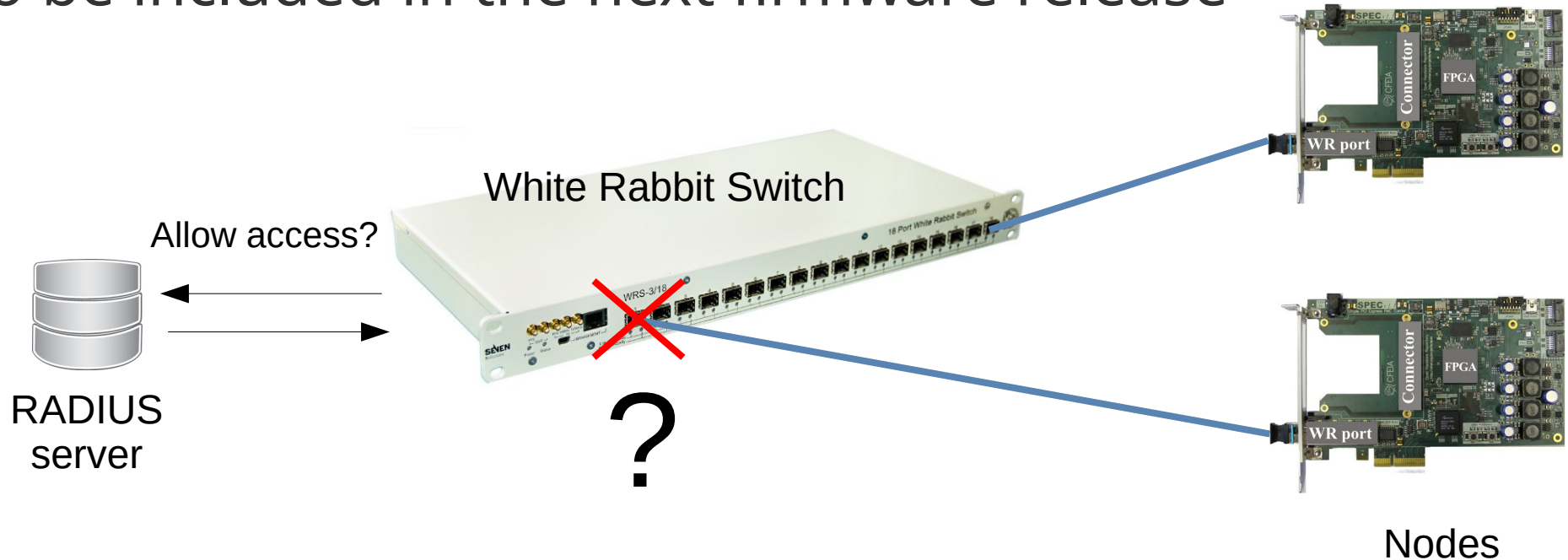
- What device is on the other side of a link?
- Supported by WR Switch and WRPC





# WRS: RADIUS

- Based on information on RADIUS server WRS can limit access to WR network
- Uses VLANs to limit access
- To be included in the next firmware release



# WRS: Configuration file

Applied at startup, contains:

- Management interface's configuration
- Timing configuration (calibration values, mode)
- Remote log server address
- Log verbosity level
- VLANs configuration
- and more

# WRS: Configuration file

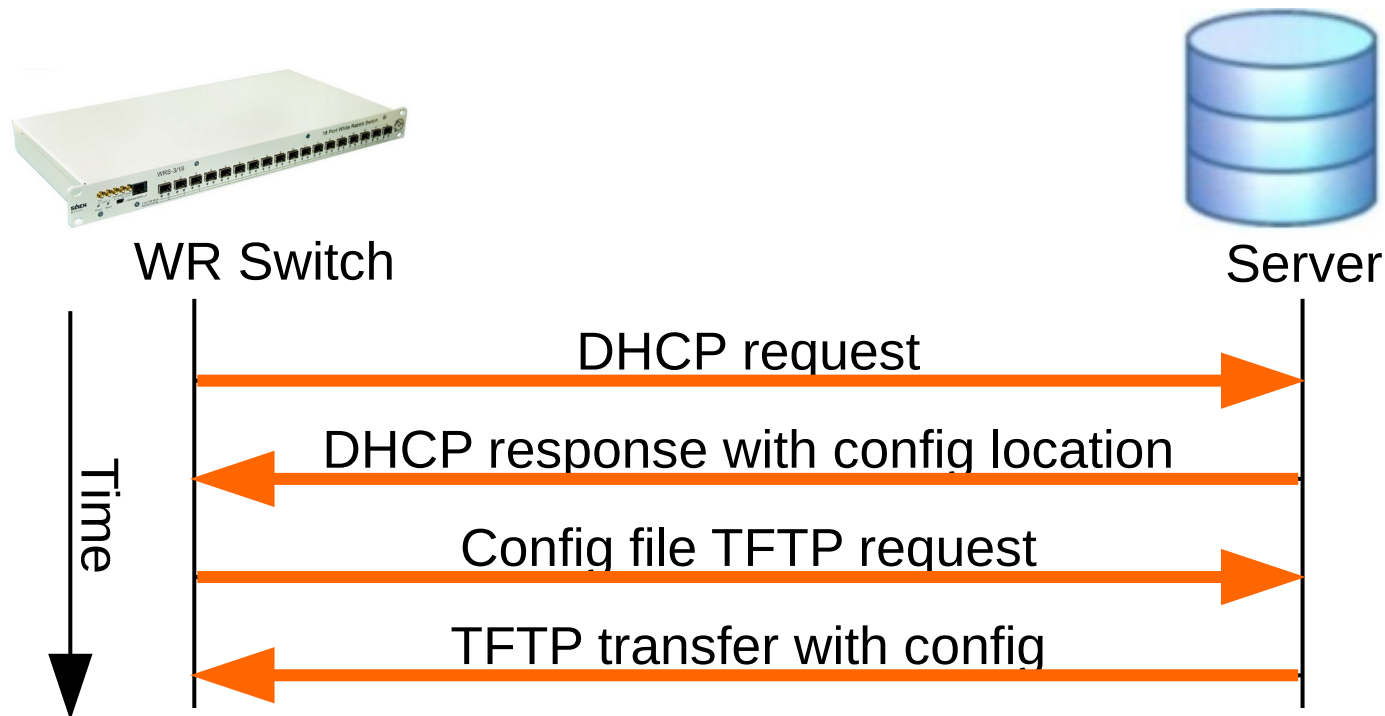
- Kconfig format
  - The same as used by Linux Kernel
  - {key}={value} format

```
CONFIG_ETH0_DHCP=y
# CONFIG_ETH0_DHCP_ONCE is not set
# CONFIG_ETH0_STATIC is not set
CONFIG_HOSTNAME_DHCP=y
# CONFIG_HOSTNAME_STATIC is not set
[...]
CONFIG_REMOTE_SYSLOG_SERVER="be-co-tracing"
CONFIG_REMOTE_SYSLOG_UDP=y
CONFIG_WRS_LOG_HAL="daemon.info"
CONFIG_WRS_LOG_LEVEL_HAL="0"
[...]
#
# Port Timing Configuration
#
CONFIG_PORT01_PARAMS="name=wri1,proto=raw,tx=223897,rx=226273,role=master,fiber=0"
CONFIG_PORT02_PARAMS="name=wri2,proto=raw,tx=224037,rx=226377,role=master,fiber=0"
CONFIG_PORT03_PARAMS="name=wri3,proto=raw,tx=224142,rx=226638,role=master,fiber=0"
CONFIG_PORT04_PARAMS="name=wri4,proto=raw,tx=224313,rx=226471,role=master,fiber=0"
```



# WRS: Config file handling

- Local on a switch
- Retrieved from a network at boot (via TFTP, FTP or HTTP)
- Path to a config provided in a DHCP response



# WRS: Editing config file

- In text editor
- Kconfig tools (make menuconfig, make nconfig etc.)

```
.config - White Rabbit Switch configuration

White Rabbit Switch configuration
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenu
----). Highlighted letters are hotkeys. Pressing <Y> includes, <N> excludes, <M>
modularizes features. Press <Esc><Esc> to exit, <?> for Help, </> for Search.
Legend: [*] built-in [ ] excluded <M> module < > module capable

(6.0) Firmware version
() Hardware version
() Additional info about dot-config
Source for a run-time replacement of dot-config (Try to get the URL to a
Source for a run-time replacement of leap seconds file (Use local leap se
(wrs_release_br2_config) Configuration file for Buildroot
Local Network Configuration --->
Port Timing Configuration --->
SFP and Media Timing Configuration --->
Timing Mode (Boundary Clock) --->
PTP options --->
PPS generation --->
PTP Port Assignment (Generate ppsi.conf based on the PORTxx_INSTyy_z para
Management configuration --->
External clk2 clock signal configuration --->
NIC throttling configuration --->
[ ] Enable 50ohm termination for 1-PPS input
Custom boot script configuration --->
LLDP options --->
Radius-vlan options --->
[ ] Disable web interface
Developer options --->
RTU HP mask --->
VLANs --->

<Select> < Exit > < Help > < Save > < Load >
```





# WRS: Editing config file

- In text editor
- Kconfig tools (make menuconfig, make nconfig etc.)
- Web interface (not recommended!)

White-Rabbit Switch Manager

Dashboard PPSi Setup VLAN Setup Endpoint Mode Switch Management About

**MAIN MENU**

- Dashboard
- Network Setup
- PPSi Setup
- Endpoint Mode
- VLAN Setup
- Switch Management
- Advanced Mode

User: [admin](#) ([logout](#))

**DASHBOARD**

**Switch Info**

Hostname	192.168.1.10
IP Address	192.168.1.10
Mac Address	02:34:56:78:9A:BC
Kernel Version	2.6.39-wr-switch
Firmware Version	v4.1.1-324-gd64227f+
Hardware Version	scb: v000backplane: v3.30
FPGA Version	UNKNOWN
Manufacturer	Seven Solutions
Serial Number	UNKNOWN
Kernel Compiled Date	#1 Mon Nov 17 11:00:54 CET 2014

**WRS Services**

White-Rabbit Date	98.184298000 TAI 1970-01-01 00:01:38.184298000 TAI 1970-01-01 00:01:03.184298000 UTC
PPSi	[on]
Net-SNMP Server	[on] ( port 161 )
NTP Server	

White-Rabbit OHR

White Rabbit Project - Open Hardware and Source Project [White-Rabbit OHR](#)

LIGHTTPD php



# WRS: Editing config file

- In text editor
- Kconfig tools (make menuconfig, make nconfig etc.)
- Web interface (not recommended!)
- Custom tool, CERN: Controls Configuration Data Editor (CCDE)

The screenshot shows the 'Switch Configuration' web interface. On the left, there are two sidebars: 'Switch browser' and 'Version browser'. The 'Switch browser' sidebar contains a table with columns 'Switch' and 'Version', listing switches like 'wrs-test4', 'wrs-test1', 'wrs-test2', and 'wrs-test3'. The 'Version browser' sidebar contains a table with columns 'Hardware' and 'Firmware', listing versions like '3.4', '3.4', and '3.3'. The main area is divided into tabs: 'Basic', 'Advanced', and 'Ports'. The 'Basic' tab is active, showing fields for 'Host name' (wrs-test1), 'Timing mode' (Boundary Clock selected), 'Hardware Version' (3.4), 'Firmware Version' (5.0), 'NTP server' (ip-time-1.cern.ch), and 'Syslog server' (be-co-tracing). Below these fields is an 'Additional details' section with a table containing information about the switch, including 'Computer Name', 'Location', 'Responsible', 'Operational Support', 'HCP Image Path', 'HCP Server', 'OS', 'Operation', 'Diamon', 'Layout', and 'MTF'. At the bottom, there are buttons for 'Remove switch', 'Discard changes', and 'Save switch'.

Switch	Version
wrs-test4	3.4 / 5.0
wrs-test1	3.4 / 5.0
wrs-test2	3.4 / 5.0.1
wrs-test3	3.4 / 5.0

Hardware	Firmware
3.4	5.0
3.4	5.0.1
3.3	5.0.1

Computer Name	Location	Responsible	Operational Support
wrs-test1			

HCP Image Path	HCP Server	OS	Operation	Diamon	Layout	MTF
/white_rabbit/config-	CS.CERN.CH	LINUX	EMBEDDED			

Step 1: Web interface for DB, it generates WR Switch config in JSON format

Step 2: Switch config is generated from JSON format by generator:

<https://gitlab.cern.ch/white-rabbit/wrs-config-generator>



# WRS: Editing config file

- In text editor
- Kconfig tools (make menuconfig, make nconfig etc.)
- Web interface (not recommended!)
- Custom tool, CERN: Controls Configuration Data Editor (CCDE)
- Custom scripts to distribute config files (GSI)

Note: some features need to be enabled and configured in a config file to work

# WRPC: Configuration

- Text file, syntax the same as WRS config
- Kconfig tools on host (make menuconfig, make nconfig etc.)
- Applied at build time
- For some features the configuration can be done by a shell command in run-time
- Startup script defined:
  - At build time
  - Run-time (saved in flash)

Note: To keep the footprint small many features are disabled by default.

# WRS: other supported protocols

- VLANs (limit access between network parts)
- Syslog (logging)
- Kerberos and LDAP (authentication and authorization)

# WRPC: other supported protocols

- VLANs (limit access between network parts)
- Syslog (logging), events like:
  - boot up
  - link down/up
  - sync lost
  - sync recovered
  - Temperature over threshold
- BOOTP
- Netconsole

# Agenda

- A few words about myself
- Short overview of White Rabbit network and equipment
- Supported protocols for monitoring and management
- **Command line tools**



# WRS: wr\_mon

- The best CLI tool to start with
- Gives many important information about WR Switch status and configuration:
  - Build version  
(of the tool! Not of the entire firmware.  
For the deployed firmware should not matter)
  - Link status
  - PTP/WR configuration
  - MAC of the peer (\*)
  - PLL locking status
  - Timing mode
  - WR time
  - Servo status (if in slave mode)
- Similar tool exists for WRPC (gui)

(\*) - available in the next firmware release

```
WR Switch Sync Monitor WP3a-wrpc_fixes-23-g7f9cb63c-dirty [q = quit]

WR time (TAI)      : 2021-10-05 00:09:15.015536  Leap seconds: 37
Switch time (UTC) : 2021-10-05 00:08:38.015496  TAI-UTC      : +37.000040
TimingMode: BC    PLL locking state: LOCKED

----- HAL ----- PPSI -----
Iface| Freq| Inst| Name      | Config | MAC of peer port | PTP/EXT/PDETECT States | Pro | VLANs
-----|-----|-----|-----|-----|-----|-----|-----|-----|
wri1  | Lock | 0   | wri1-1-wr-raw | slave  | [REDACTED]       | SLAVE /IDLE /EXT_ON  | V-W | 31
*wri2  |      | 1   | wri2-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri3  |      | 2   | wri3-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
wri4  |      | 3   | wri4-1-wr-raw | master | 00:00:00:00:00:00 | MASTER  /IDLE /WA_MSG | R-W |
*wri5  |      | 4   | wri5-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri6  |      | 5   | wri6-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri7  |      | 6   | wri7-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri8  |      | 7   | wri8-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri9  |      | 8   | wri9-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri10 |      | 9   | wri10-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri11 |      | 10  | wri11-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri12 |      | 11  | wri12-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri13 |      | 12  | wri13-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri14 |      | 13  | wri14-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri15 |      | 14  | wri15-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri16 |      | 15  | wri16-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri17 |      | 16  | wri17-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |
*wri18 |      | 17  | wri18-1-wr-raw | master | 00:00:00:00:00:00 | DISABLED /IDLE /NONE  | R-W |

Pro - Protocol mapping: V-Ethernet over VLAN; U-UDP; R-Ethernet

----- Synchronization status -----
Servo state:      wri1:White-Rabbit: TRACK_PHASE

+- Timing parameters -----
meanDelay      : 169.628 nsec
delayMS        : 169.651 nsec
delayMM        : 1240.402 nsec
delayAsymmetry : 0.023 nsec
delayCoefficient : +0.00026786999999987 fpa : 1235332333756144
ingressLatency : 225.959 nsec
egressLatency  : 224.295 nsec
semistaticLatency : 0.000 nsec
offsetFromMaster : 0.002 nsec
Phase setpoint : 9.851 nsec
Skew           : 0.000 nsec
Update counter : 1371 times
Master PHY delays TX: 224.642 nsec RX: 226.250 nsec
Slave PHY delays TX: 224.295 nsec RX: 225.959 nsec

----- Temperatures -----
FPGA: 29.31 PLL: 47.69 PSL: 46.88 PSR: 48.44
```





# WRS: More CLI tools

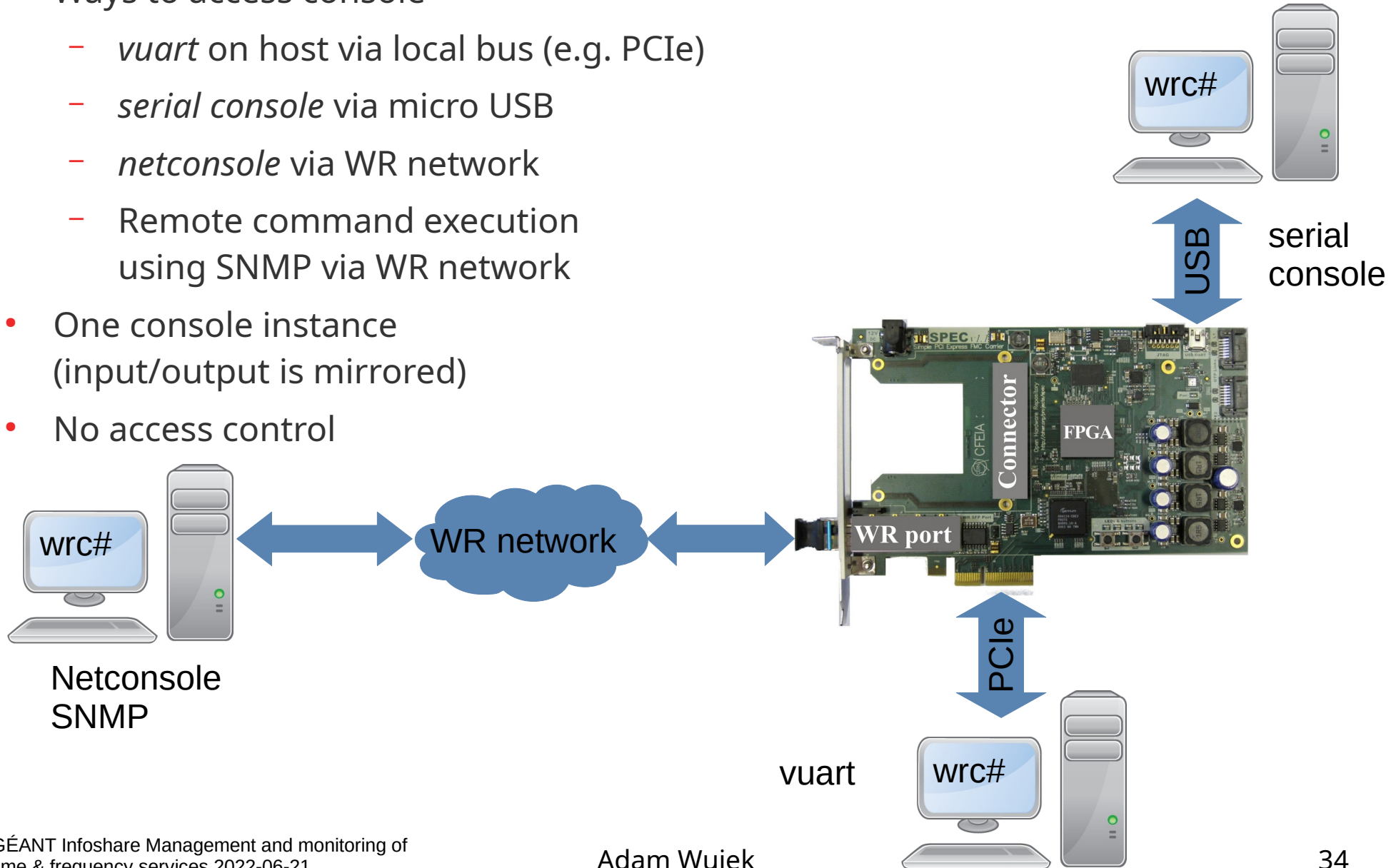
- More CLI tools available:
  - wrs\_shmem\_dump – display internal data structures of WR specific processes
  - rtu\_stat – display switching tables
  - wrs\_vlans – display vlans configuration
  - wr\_pstats – detailed interface statistics
  - Number of files in /tmp – status of several subsystems
  - ptpdump, tcpdump & wireshark (with WR dissector) – PTP/WR frames analysis
  - wrs\_dump.sh – remotely create dump of WRS state
- More details about these tools can be found in:
  - *WRS user manual*
  - presentation “A quick tour through the available diagnostic and monitoring tools for White Rabbit Networks”

[https://ohwr.org/project/white-rabbit/wikis/uploads/c5a4ca468edc2251874c3694867e12fc/tools\\_diagnostic\\_monitoring.pdf](https://ohwr.org/project/white-rabbit/wikis/uploads/c5a4ca468edc2251874c3694867e12fc/tools_diagnostic_monitoring.pdf)



# WRPC: console

- Ways to access console
  - *vuart* on host via local bus (e.g. PCIe)
  - *serial console* via micro USB
  - *netconsole* via WR network
  - Remote command execution using SNMP via WR network
- One console instance (input/output is mirrored)
- No access control



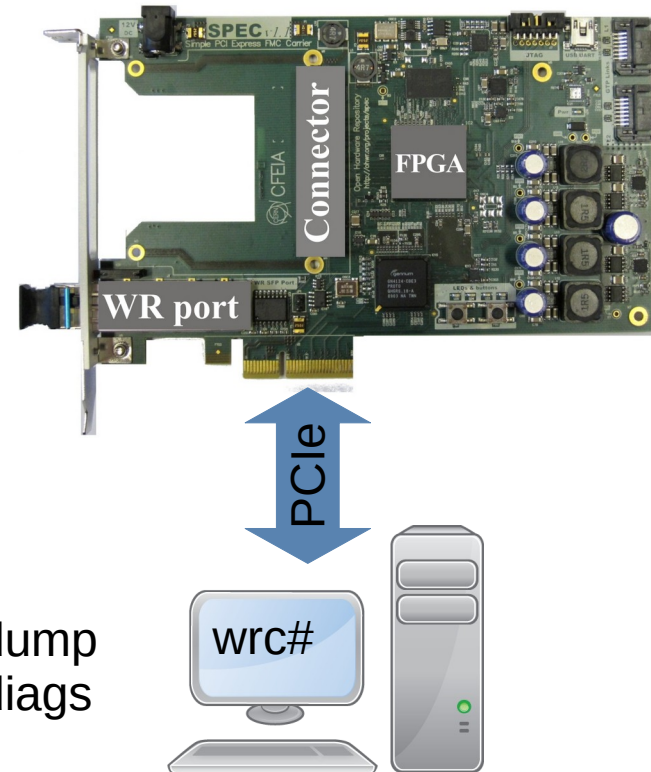
# WRPC: more CLI tools

- Tools working over local bus:
  - wrpc-dump – interpret data structures in node's memory
  - wrpc-diags – display node's status (similar to gui command)

More details about these tools can be found in:

- White Rabbit PTP Core User's Manual
- presentation "A quick tour through the available diagnostic and monitoring tools for White Rabbit Networks",

[https://ohwr.org/project/white-rabbit/wikis/uploads/c5a4ca468edc2251874c3694867e12fc/tools\\_diagnostic\\_monitoring.pdf](https://ohwr.org/project/white-rabbit/wikis/uploads/c5a4ca468edc2251874c3694867e12fc/tools_diagnostic_monitoring.pdf)



wrpc-dump  
wrpc-diags



# Thank you!





# Questions?



# Further reading

- Managing Your Timing System As A Standard Ethernet Network, A. Wujek, <https://accelconf.web.cern.ch/icalepcs2017/papers/tush303.pdf>
- A quick tour through the available diagnostic and monitoring tools for White Rabbit Networks, A. Wujek, [https://ohwr.org/project/white-rabbit/wikis/uploads/c5a4ca468edc2251874c3694867e12fc/tools\\_diagnostic\\_monitoring.pdf](https://ohwr.org/project/white-rabbit/wikis/uploads/c5a4ca468edc2251874c3694867e12fc/tools_diagnostic_monitoring.pdf)

